

MULTIMEDIA



UNIVERSITY

STUDENT ID NO

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MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2016/2017

ETM7136 – DIGITAL COMMUNICATION SYSTEMS AND DESIGN (M.Eng.Tele)

8 OCTOBER 2016
2.30 p.m - 5.30 p.m
(3 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 8 pages (including the cover page) with 4 Questions only.
2. Attempt all of the **FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please write all your answers in the Answer Booklet provided.

Question 1

- (a) The probability density function of a signal power, X , coming from an infrared (IR) remote control is measured and is plotted as in Figure Q1.

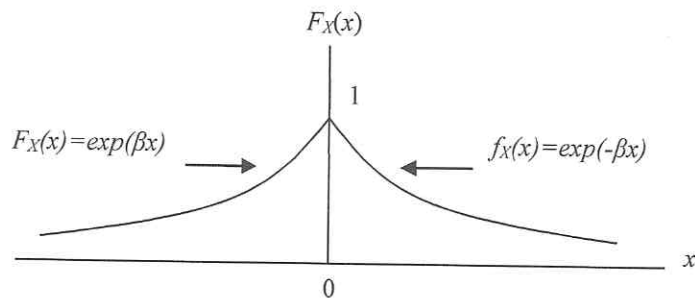


Figure Q1

- (i) Find the value of the constant β . [2 marks]
 - (ii) What is the probability that the signal falls between -1 and 1 volts? [2 marks]
 - (iii) It is calculated that the probability the signal received is between $-\alpha$ volts and $+\alpha$ volts is 50%. What is the value of α ? [2 marks]
 - (iv) Find the cumulative distribution function (CDF) of the signal. [3 marks]
- (b) A cordless phone has a signal-to-noise ratio (SNR) of 25 dB and passes voice over the frequency range of 30 Hz to 3 kHz. The cordless phone is to be designed to transmit and receive voice simultaneously (i.e. full duplex) over this line without errors.
- (i) What are the maximum transmitting and receiving data rates if the whole frequency range of 30 to 3 kHz is used simultaneously for transmitting and receiving? [2 marks]
 - (ii) If the frequency range is reduced to only between 30 Hz to 2 kHz for simultaneous transmission but the same data rate is expected to be as what was calculated in part (i) above, what would be the required SNR value? [2 marks]
 - (iii) Calculate the maximum frequency that you can go from 30 Hz if the SNR is 35 dB and the data rate is as calculated in part (i) above. [2 marks]

Continued

Question 1

- (c) The Malaysian Commission for Multimedia and Communication (MCMC) has released a tender to study a new spectrum for a new communication signal waveform $V(t)$. You have been selected to study the power spectral density (PSD) of this particular waveform. The two-sided PSD of the waveform is given by

$$G_V(f) = \begin{cases} 2.5 \times 10^{-3} \pi \times \cos(5 \times 10^{-5} \pi f), & -10 \text{ kHz} \leq f \leq 10 \text{ kHz} \\ 0, & \text{elsewhere} \end{cases}$$

- (i) Calculate the normalized average power in $V(t)$ over all frequency bands. [2 marks]
- (ii) Find the normalized average power contained in the frequency band between 3 to 8 kHz. [2 marks]
- (iii) If the normalized average power contained between 0 to x kHz is calculated to be 60 W, what is the value of the frequency x ? [2 marks]
- (d) A communication signal is to be transmitted using a uniformly sampled digital transmission. The signal can be written as:

$$x(t) = 5 \cos(200t + \pi/3) + 4 \cos(400t + \pi/6) + 20 \sin(600t)$$

- (i) What is the maximum allowable time interval between sample values that will ensure perfect signal reproduction? [2 marks]
- (ii) If we want to reproduce 1 hour of this waveform, how many sample values need to be stored? [2 marks]

[2 marks]

Question 2

- (a) In the video compact disc (VCD) digital audio video system, an analog signal is digitized so that the ratio of the peak-signal power to the peak-quantization noise power is at least 50 dB. The sampling rate is 44.1 ksamples/s.

- (i) How many quantization levels are needed for $(S/N_q)_{\text{peak}} = 50$ dB?

- (ii) How many bits per sample are needed for the number of levels found in part (i)? [3 marks]

- (iii) What is the data rate in bits/s? [3 marks]

[3 marks]

Continued

- (b) Consider that you desire a digital transmission system, such that the quantization distortion of any audio source does not exceed $\pm 0.5\%$ of the peak-to-peak analog signal voltage. If the audio signal bandwidth and the allowable transmission bandwidth are each 2000 Hz, and sampling takes place at the Nyquist rate, what value of bandwidth efficiency (bits/s/Hz) is required?

[4 marks]

- (c) An analog signal is Pulse Code Modulation (PCM) formatted and transmitted using binary waveforms over a channel that is bandlimited to 400 kHz. Assume that 128 quantization levels are used and that the overall equivalent transfer function is of the raised cosine type with roll-off $r=0.5$.

- (i) Find the maximum bit rate that can be used by this system without introducing intersymbol interference (ISI).

[3 marks]

- (ii) Find the maximum bandwidth of the original analog signal that can be accommodated with these parameters.

[3 marks]

- (d) A binary communication system transmits signals $s_i(t) (i=1,2)$. The receiver test statistic $z(T) = a_i + n_0$, where the signal component a_i is either $a_1 = +1$ or $a_2 = -1$ and the noise component n_0 is uniformly distributed, yielding the conditional density functions $p(z | s_i)$ given by

$$p(z | s_1) = \begin{cases} \frac{1}{2} & \text{for } -0.2 \leq z \leq 1.8 \\ 0 & \text{elsewhere} \end{cases}$$

and

$$p(z | s_2) = \begin{cases} \frac{1}{2} & \text{for } -1.8 \leq z \leq 0.2 \\ 0 & \text{elsewhere} \end{cases}.$$

Find the probability of a bit error, P_B , for the case of equally likely signaling and the use of an optimum detection threshold.

[6 marks]

Question 3

- (a) For a binary data sequence of [10110001], sketch the bandpass modulated waveform for 4-ASK (Amplitude Shift Keying) and binary-FSK (Frequency Shift Keying) modulation. You can make appropriate assumption on the bit-to-symbol mapping.

[6 marks]

Continued

- (b) Figure Q3 shows two quadrature phase-shift-keying (QPSK) constellations for a $\pi/4$ -QPSK modulator. Assume that the modulation starts from scheme (a). Obtain the carrier phase shifts when the input data stream is 10 11 01 00 10 10 10, where the leftmost bits are first applied to the modulator.

[4 marks]

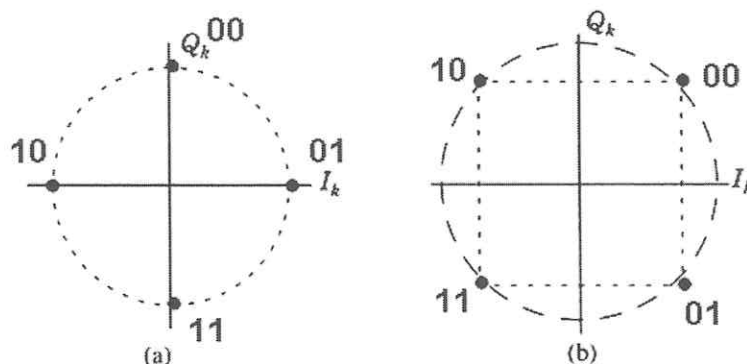


Figure Q3

- (c) Frequency-hopping spread-spectrum (FH-SS) signals are commonly used in digital communications systems that require anti-jamming protection. Distinguish the two types of FH-SS signals.

[4 marks]

- (d) Orthogonal frequency-division multiplexing (OFDM) is a digital multi-carrier modulation scheme widely used in communication systems.

- (i) Give two examples of modern communication systems that use OFDM.

[2 marks]

- (ii) With the aid of diagrams, describe briefly the basic principle of OFDM and elaborate on how intersymbol interference can be mitigated effectively using this modulation scheme.

[6 marks]

- (iii) An adaptive version of OFDM called discrete-multitone modulation (DMT) is commonly used in digital subscriber loop (DSL) systems for providing Internet access through the copper telephone lines. Describe two main differences between DMT and wireless OFDM systems.

[3 marks]

Continued

Question 4

- (a) Consider an frequency-hopping/ M -ary frequency-shift keying (FH/MFSK) system shown in Figure Q4. The PN sequence generator can produce $(2^{20}-1)$ states. Each state of the register dictates a new centre frequency within the hopping band. The minimum step size between centre frequencies (hop to hop) is 200 Hz. The clock rate of the PN sequence generator is 2 kHz. Assume that 8-FSK modulation is used and that the data rate is 1.2 kbits/s.

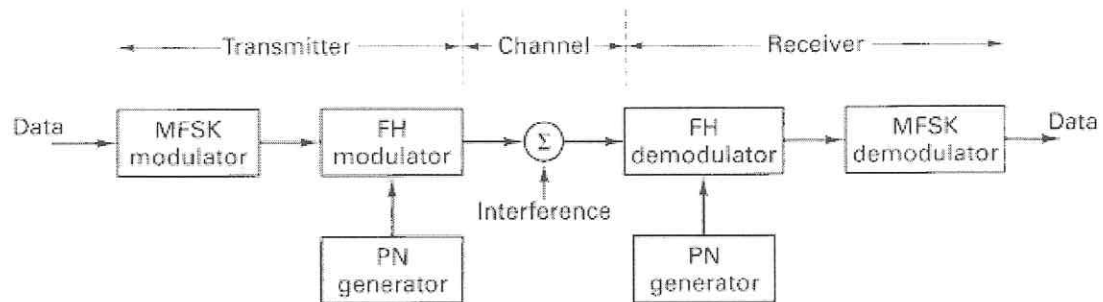


Figure Q4

Determine the following:

- (i) The hopping bandwidth. [2 marks]
 - (ii) The chip rate. [1 mark]
 - (iii) The number of chips in each data symbol. [2 marks]
 - (iv) The processing gain. [2 marks]
- (b) Reed-Solomon (RS) codes are the most frequently used block error correction codes in digital applications. Briefly describe the important properties of RS codes. Explain why they are suitable for correcting burst bit errors but relatively sensitive to evenly spaced (bit) errors. [6 marks]
- (c) A convolutional code is described by the following impulse responses:
- $$g_1 = [1 \ 0 \ 1], \ g_2 = [1 \ 1 \ 1], \ g_3 = [1 \ 1 \ 1]$$
- (i) Sketch the encoder corresponding to this code. [2 marks]
 - (ii) Sketch the state-transition diagram for this code. [2 marks]
 - (iii) Sketch the trellis diagram for this code. [2 marks]

Continued

- (d) Describe briefly the principle of coded modulation. Discuss, with the aid of a diagram, how an uncoded 4-PSK system which transmits 2 bits/symbol can be replaced by an 8-PSK coded modulator (transmitting 3 bits/symbol), whose overall data rate remains 2 bits/symbol.

[6 marks]

Continued

Appendix 1: Table of Fourier Transform Properties

Let $x(t) \Leftrightarrow X(f)$, $x_1(t) \Leftrightarrow X_1(f)$ and $x_2(t) \Leftrightarrow X_2(f)$; and a, b, t_o and f_o scalar quantities.	
Linearity	$ax_1(t) + bx_2(t) \Leftrightarrow aX_1(f) + bX_2(f)$
Scaling ($a \neq 0$)	$x(at) \Leftrightarrow \frac{1}{ a } X\left(\frac{f}{a}\right)$
Time Shifting	$x(t - t_o) \Leftrightarrow X(f)e^{-j2\pi ft_o}$
Frequency Shifting	$x(t)e^{j2\pi f_o t} \Leftrightarrow X(f - f_o)$
Time Convolution	$x_1(t) * x_2(t) \Leftrightarrow X_1(f)X_2(f)$
Frequency Convolution	$x_1(t)x_2(t) \Leftrightarrow X_1(f) * X_2(f)$
Time Differentiation	$\frac{d^n}{dt^n} x(t) \Leftrightarrow (j2\pi f)^n X(f)$
Frequency Differentiation	$(-jt)^n x(t) \Leftrightarrow \frac{d^n}{df^n} X(f)$
Time Integration	$\int_{-\infty}^t x(\tilde{t}) d\tilde{t} \Leftrightarrow \frac{X(f)}{j2\pi f} + \frac{1}{2} X(0)\delta(f)$
Frequency Integration	$x(t)u(t) \Leftrightarrow \int_{-\infty}^f X(\tilde{f}) d\tilde{f}$

End of Paper